Positioning of Nanocrystals on Prestructured Substrates

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Many device concepts require the combination of different materials in a structured manner with high precision on the nanometer scale. Examples could be magnetic storage media or photonic devices. In some special cases and very few material systems, organized growth on prestructured substrates has been demonstrated but generally it is hardly possible to combine materials of very different chemical nature. A particularly interesting class of materials are nanocrystals which can be synthesized at moderate costs from a variety of materials. In suitable arrangements, they can be utilized for lasers or high density data storage, sensors, solar cell sensitizers and many more.

In this contribution we present a versatile and simple method that allows positioning of nanocrystals on prestructured substrates with potential not only for lab scale application but also for volume production and it works for a wide range of material combinations and structures. Here we use Si- or oxidised Si wafers as substrates. These are patterned by the projection maskless nanopatterning method[1] using 10 keV Ar^+ multibeams, a tool set developed by IMS Nanofabrication.

The patterned substrates are covered by a dispersion of the nanocrystals, typically with a few nanometers in diameter, in a volatile solvent. Then we use a mechanical polishing procedure on a suitable polishing cloth to manoeuvre the nanocrystals into pits or rims in the substrate. For pits the number of nanocrystals per pit depends on the ratio of pit diameter and that of the nanocrystals and we demonstrate down single nanocrystal occupation of rectangular pit arrays (65 nm pitch, 20 nm pit diameter) on fields of 25x25 μm^2. We show that the magnetic properties of ferromagnetic iron-oxide based nanocrystals are preserved by this procedure making use of magnetic force microscopy. We also show that CdSe nanocrystals can be positioned in rims on an oxidised wafer to form waveguides and they show unimpaired, very bright photoluminescence after this procedure.

Acknowledgement

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[1] E. Platzgummer, H. Loeschner, and G. Gross., J. Vac. Sci. Technol. B26, 2059 (Nov/Dec 2008)

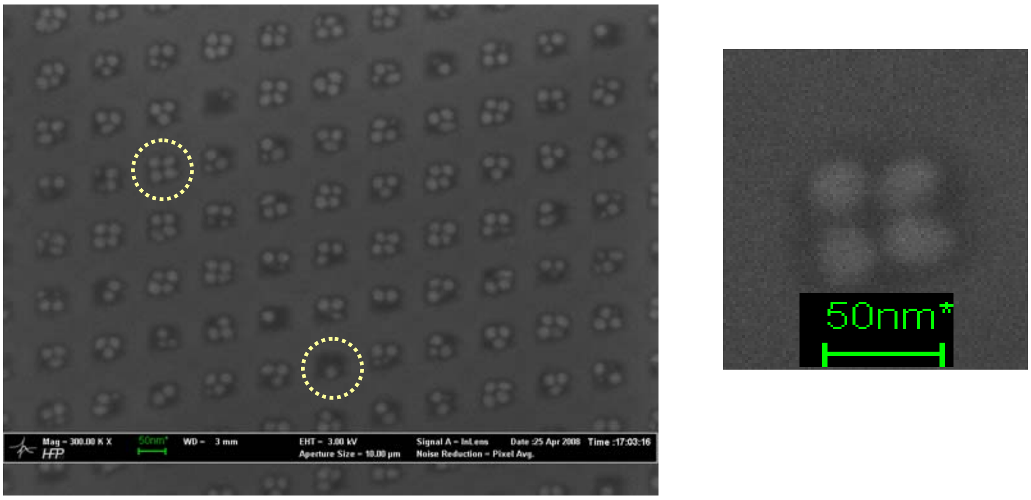

***Fig. 1**: Nanopatterning of Si surface with 10 keV Ar^{+} ion multi-beam and nanopositioning of nanocrystals.*

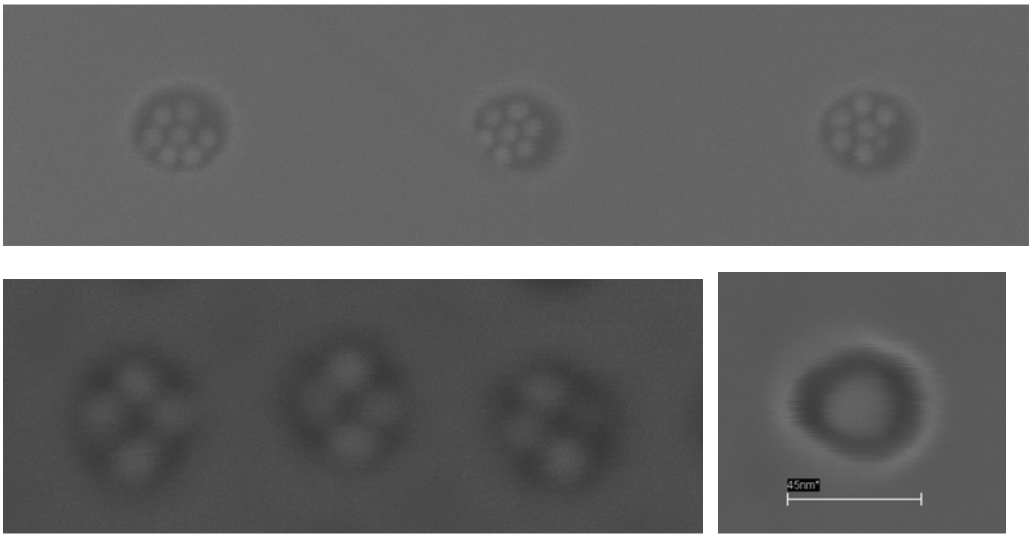

***Fig. 2**: Positioning of a few down to a single nanocrystal per pit. In the latter example, the hole is 45 nm in diameter.*